



National Aeronautics and  
Space Administration

**Goddard Space Flight Center**  
Greenbelt, MD 20771

# **WORKMANSHIP MANUAL FOR ELECTROSTATIC DISCHARGE CONTROL**

**(EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES)**

<p>NOT MEASUREMENT SENSITIVE</p>
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Responsible Organization:

300 / OFFICE OF SYSTEMS SAFETY AND MISSION ASSURANCE

CHECK THE GSFC CENTRALIZED CONFIGURATION MANAGEMENT SYSTEM AT  
<http://gdms.gsfc.nasa.gov/> TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

## CHANGE HISTORY LOG

Revision	Effective Date	CCR date	Description of Changes
-	04/11/2005	--	Initial Release
A	05/16/2006	05/16/2006	<p>Numerous editorial and formatting changes.</p> <p>Clarified 5.5.4 for new programs.</p> <p>Clarified requirements and usage of Test Log.</p> <p>Minor changes to required measurements in Table 7-1.</p> <p>Clarified requirements throughout with proper use of “shall” and other verbiage consistent with NASA Directive requirements.</p> <p>Updated tailoring requirements in 7.20.</p> <p>Added requirements throughout for documenting problems and non-conformances in accordance with GPR 5340.2.</p> <p>In section 9, clarified trending requirements and addressing of failed areas.</p> <p>Updated forms and labels in Section 10 and Appendix C.</p> <p>Minor updates to other appendices.</p>

# GSFC STANDARD

## FOREWORD

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This manual was created specifically for the use of the GSFC.

In order to comply with paragraph 6.1 of ANSI/ESD S20.20-1999 and meet the standards of the GSFC Electrostatic Discharge (ESD) program, this publication:

- a. Prescribes the plan to be followed when implementing ANSI/ESD S20.20-1999. It replaces NASA–STD–8739.7(Cancelled) at GSFC.
- b. Describes basic considerations necessary to ensure static free work areas.
- c. Establishes the supplier’s responsibility to train and certify personnel.
- d. May be used by suppliers performing work for GSFC as their means to comply with the requirement of ANSI/ESD S20.20–1999 for their own ESD plan.

***NOTE: FOR THE PURPOSE OF THIS DOCUMENT, THE TERM SUPPLIER SHALL BE DEFINED AS IN-HOUSE GSFC and GSFC CONTRACTORS.***

This document is controlled and maintained by Code 300, Office of Systems Safety and Mission Assurance. Questions concerning application of this publication shall be referred to Code 300 or its designated representative.

This Manual provides the ESD Control Program Plan (CPP), Compliance Verification and ESD Technical Requirements specified in ANSI/ESD S20.20-1999 paragraph 6.1.

The guide for the development of this manual was the ESD TR20.20 HANDBOOK, published by the ESD Association. Technical Reports are normally not considered ESDA approved documents, but in the case of this Handbook is a compiled reference and interpretation of the ESDA standards and guidance on how to create an ESD Control Program Plan for ANSI/ESD S20.20.

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# 1 SCOPE

## 1.1 Purpose

The purpose of this document is to define the minimum requirements (per ANSI/ESD S20.20-1999) for protection against electrostatic discharge (ESD) damage to ESD sensitive (ESDS) devices, and to ensure reliable performance of GSFC spaceflight and ground support hardware.

This Workmanship Manual defines and implements the ESD Control Program at GSFC.

## 1.2 Applicability

In accordance with GPR 8730.6, suppliers performing work for GSFC shall use this document.

This publication sets forth an ESD control plan & technical requirements for items that are ESD Sensitive (ESDS) (excluding electrically initiated explosive devices) in accordance with ANSI/ESD S20.20-1999 paragraphs 6.1 and 6.2.

The practices described here are generally suitable for the ESD sensitivity levels of the Human Body Model (HBM) Classes 0 and 1A and Machine Model (MM) Class M1. See paragraph 5.2.

***Note: ESD damage can often go undetected at the time it occurs and parts may continue to operate satisfactorily for a while, but then fail prematurely.***

In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will” and descriptive material by “is.”



## 2 APPLICABLE DOCUMENTS

ANSI/ESD S20.20–1999	ESD Association Standard for the Development of an Electrostatic Discharge Control Program for – Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ANSI/ESD S6.1–1999	Grounding - Recommended Practices
ANSI/ESD TR20.20–2000	Control Program Handbook, Technical Requirements
ESD ADV1.0-2004	ESDA Glossary of Terms
ESD SP3.3–2000	Periodic Verification of Air Ionizers
ESD STM2.1-1997	Protection of ESD Sensitive Items – Garments
ESD STM5.1–2001	Human Body Model (HBM) – Component Level
ESD STM5.2-1999	Machine Model (MM) – Component Level
ESD STM5.3-1-1999	Charged Device Model (CDM) – Component Level
ESD STM7.1–2001	Resistive Characterization of Materials – Floor Materials
ESD STM12.1–1997	Seating Resistive Measurements
ESD STM13.1–2000	Electrical Soldering/De-soldering Hand Tools
GPR 8730.1	Calibration and Metrology
GPR 8730.6	Electrostatic Discharge (ESD) Control
GPR 5340.2	Control of Non Conformances

### 3 DEFINITIONS AND ACRONYMS

#### 3.1 Definitions

The following definitions apply to terms used in this manual:

- a. **Assembly.** A functional subdivision of a component, consisting of parts or subassemblies, which perform functions necessary for the operation of the component as a whole. Examples: regulator assembly, power amplifier assembly, gyro assembly, etc.
- b. **Certificate of Completion of Training.** The actual certificate issued or the wallet size card given to the trainee at the time of training.
- c. **Certification.** The act of verifying and documenting that the personnel, facilities, equipment, processes and materials comply with the requirements of this document.
- d. **Certification of Competence.** The act of verifying and documenting that personnel are competent to perform work in an ESD protected area as required by this document.
- e. **Certification of Training.** The act of verifying and documenting that personnel have completed training required by this document.
- f. **Charged Device Model.** A specified circuit characterizing an electrostatic discharge, which results when a device isolated from ground is first charged and then subsequently grounded.
- g. **Component.** A functional subdivision of a system, generally a self-contained combination of assemblies performing a function necessary for the system's operation. Examples: power supply, transmitter, gyro package, etc.
- h. **Contractor.** The individual(s) or concern(s) who enter into a prime contract with the Government.
- i. **Conductive Material.** A material that has a surface resistivity of  $<10^5$  ohms per square or a volume resistivity  $<10^4$  ohms-cm.
- j. **Deviation.** A specific written authorization, granted before the fact, to depart from a particular requirement of specification or related document. A deviation is usually granted for a particular item, and/or a specific series of units, and/or a specified period of time.
- k. **Electrostatic Discharge (ESD).** A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.
- l. **ESD ADV... Advisory Documents** are not standards, but provide general information for the industry or additional information to aid in better understanding of ESD Association standards.
- m. **ESD DS...** Draft standards, draft standard test methods, and draft standard practices are subject to revision before being issued as full standards.
- n. **ESD S...** Standards have completed the industry comment and review process, and have been approved by the ESD Association Standards Committee as final standards documents.
- o. **ESD SP... Standard Practices** have completed the industry comment and review process, and have been approved by the ESD Association Standards Committee as final standards documents.
- p. **ESD STM... Standard Test Methods**, have completed the industry comment and review process, and have been approved by the ESD Association Standards Committee as final standards documents.
- q. **ESD TR... Technical Report**, a collection of technical data or test results published as an informational reference on a specific material, product, system or process. The opinions expressed in a technical report are the opinions of the author(s) and may or may not be endorsed by the ESD Association.

- r. **ESD Program Monitor.** An individual who is trained and certified to be in charge of an ESD protected area.
- s. **ESD Protected Area.** An area that is constructed and equipped with the necessary ESD-protective materials and equipment to limit ESD voltage below the sensitivity level of ESDS items handled therein.
- t. **ESD-Protective Material.** Material capable of one or more of the following functions: limiting the generation of static electricity; safely dissipating electrostatic charges over its surface or volume; or providing shielding from ESD spark discharge or electrostatic fields.
- u. **ESD-Protective Packaging.** Packaging with ESD-protective materials to prevent damage to ESDS items.
- v. **ESD Protected Workstation.** An area which is constructed and equipped with the necessary protective materials and equipment to limit damage to ESDS items handled within.
- w. **ESD Sensitive (ESDS) Items.** Electrical and electronic parts, assemblies and equipment which are sensitive to ESD voltages or electrostatic fields.
- x. **Electrostatic Field.** A voltage gradient between an electrostatically charged surface and another surface of a different electrostatic potential.
- y. **Ground.** A mass such as earth, a ship, or a vehicle hull, capable of supplying or accepting a large electrical charge.
- z. **Groundable Point.** Any point with low impedance to ground where grounding may be attached. Usually it is the common point ground.
- aa. **Hard Ground.** A connection to earth ground either directly or through low impedance.
- bb. **Human Body Model.** An electrostatic discharge circuit that meets the set model values by conforming to waveform criteria specified in ESD-STM 5.1, characterizing the discharge from the fingertip of a typical human being.
- cc. **Insulative Material.** A material having a surface resistivity  $\geq 10^{12}$  ohms/square or a volume resistivity  $\geq 10^{11}$  ohms-cm.
- dd. **Kit.** A prepared package of parts with instructions for assembly and/or wiring a component or chassis.
- ee. **Level B Instructor.** An individual who is certified to train operators and ESD program monitors. They may be also in charge of an ESD protected area.
- ff. **Machine Model.** An electrostatic discharge simulation test based on a discharge network consisting of a charged 200 picofarad capacitor at (nominally) zero ohms of series resistance. Actual series resistance and inductance are specified in terms of the current waveform through a shorting wire. The simulation test approximates the electrostatic discharge from a machine. (See ESD STM 5.2)
- gg. **Operator.** An individual who is trained and certified to performs tasks in an ESD protected area.
- hh. **Organization.** A NASA center, support contractor, department, group or team.
- ii. **Part.** An element of a component, assembly, or subassembly which is not normally subject to further subdivision or disassembly without destruction of its designed use, e.g. a module, IC, resistor, etc.
- jj. **Soft Ground.** A connection to ground through an impedance sufficiently high to limit current flow to safe levels for personnel (normally 5 milliamperes). Impedance needed for a soft ground is dependent upon the voltage levels which could be contacted by personnel near the ground. By this definition a hard ground protected by a functional GFCI is considered a soft ground.
- kk. **Static Dissipative.** A property of a material having surface resistivity  $\geq 10^5$  but  $< 10^{12}$  ohms per square or a volume resistivity  $\geq 10^4$  but  $< 10^{11}$  ohms-cm

- ll. **Subcontractor.** An individual or concern who enters into a purchase agreement under a Government prime contract.
- mm. **Supplier.** In-house GSFC organization or GSFC support contractors.
- nn. **Surface Resistivity.** The surface resistivity is an inverse measure of the conductivity of a material and equal to the ratio of the potential gradient to the surface, where the potential gradient is measured in the direction of current flow in the material.  
***NOTE:** Surface resistivity of a material is numerically equal to the surface resistance between two electrodes forming opposite sides of a square. The size of the square is immaterial. Surface resistivity applies to both surface and volume conductive materials and has the value of ohms per square.*
- oo. **System.** A system is a functional subdivision of a spacecraft generally composed of two or more components designed to perform an operation. An instrument is considered a system.
- pp. **Verification.** The act of performing the tests and/or inspections required in Table 7-1 and reviewing ESD protected areas for compliance to the requirements of this Manual.
- qq. **Triboelectric.** Pertaining to electricity generated by friction.
- rr. **Waiver.** A specific written authorization, granted after the fact, to depart from a particular requirement of specification or related document. A waiver is usually granted for a particular item, and/or a specific series of units, and/or a specified period of time.

### 3.2 Acronyms

The following acronyms apply to terms used in this standard:

AC	Alternating Current
ATL	ESD Protected Area Test Log
CDM	Charged Device Model [for electrostatic discharge].
CMS	Continuous Monitoring System
CPG	Common Point Ground
ESD	Electrostatic Discharge
ESDA	Electrostatic Discharge Association
ESD ADV	Advisory Document
ESDS	Electrostatic Discharge Sensitive
ESD DS	Draft standards
ESD S	Standards
ESD SP	Standard Practices
ESD STM	Standard Test Methods
ESD TR	Technical Report
GSFC	Goddard Space Flight Center
GFCI	Ground Fault Circuit Interrupter
GPR	Goddard Procedural Requirement
HBM	Human Body Model [for electrostatic discharge].
MM	Machine Model [for electrostatic discharge].
NASA	National Aeronautics and Space Administration
NMTTC	NASA Manufacturing Technology Transfer Center
QA	Quality Assurance
RH	Relative Humidity
RMS	Root Mean Square
SAM	Systems Assurance Manager
WM	Workmanship Manual

## 4 GENERAL

### 4.1 General

**4.1.1** This document is a controlled document and shall be controlled by Code 300 in accordance with GPR 1410.2 and Code 300's configuration management procedures.

**4.1.2** Requests for technical changes, deviations or waivers shall be processed by Code 300 as configuration changes in accordance with Code 300's configuration management procedures. Approval by the GSFC in-house project manager is also required. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality and reliability of the hardware will not be compromised.

**4.1.3** Proposed changes to this Manual shall require review and approval by a Code 300 Configuration Control Board (CCB) that includes at least one ESD-knowledgeable individual from each of the following GSFC directorates: Codes 200, 300, 400, 500, 600 and 800.

### 4.2 Implementation

**4.2.1** Code 300 shall advise and assist suppliers and other authorized personnel in the proper and effective implementation of the provisions of this publication.

**4.2.2** When the supplier proposes to use ESD control techniques not in accordance with this publication, the supplier shall document the details of the proposed techniques and inspections, and provide appropriate test data. This documentation must be approved by GSFC as described in GPR 8730.6 prior to use.

**4.2.3** Prime contractors are responsible for flowdown of the requirements herein to their subcontractors.

### 4.3 Records

Records required by the processes described herein shall be retained in accordance with GPR 1440.8. Records shall be as follows:

Record Title	Record Custodian	Retention
Training records	Office of Human Resources and/or Supervisor, as described in GPR 3410.2	NRRS 3/33G1* -- Destroy 5 years after employee discontinues or completes training
ESD workstation records	Code 300	NRRS 8/109* -Temporary- Destroy/delete when between 2 & 15 years old. Do not retain longer than life of program/project plus 5 years.

\*NRRS – NASA Records Retention Schedules ([NPR 1441.1](#))

Applicable Supplier ESD control documents or portions thereof, approved and accepted by other NASA organizations, may be used, subject to project approval, to avoid duplication of effort.

## 5 ESD CONTROL PROGRAM

### 5.1 General

**5.1.1** This ESD Control Program meets or exceeds the requirements of ANSI/ESD S20.20-1999 as well as the NASA ESD Workmanship requirements for processing ESD sensitive equipment.

**5.1.2** Proper control of ESD is critical at every step that an electronic part may see, from part manufacturing through testing, shipment, to incorporation on printed wiring boards, boxes, etc. The requirements of this ESD Control Program Plan or equivalent (see Para. 4.2.3) shall also be applied to subcontractors and suppliers. This Plan may be applied to other organizations such as parts suppliers and test labs to provide continuous protection for ESDS parts, assemblies and equipment.

### 5.2 Certification of ESD Protected Areas

**5.2.1** An ESD protected area may be a single workstation, laboratory, room, building or any area with pre-designed boundaries that contains materials and equipment designed to limit damage by electrostatic discharge.

**5.2.2** Each ESD protected area shall have a designated ESD program monitor responsible for that area.

**5.2.3** When an ESD protected area is not maintained the workstation(s) shall be marked as “Not Currently in Use” and the ESD program monitor in charge of the area may reactivate them by verifying they pass the tests of Table 7-1. A new Verification Sticker (See Appendix C) shall be affixed to the workstation(s). Also filled-in ATLs (See appendix B) shall be used to demonstrate that the area was inactive for less than six months.

**5.2.4** An ESD protected area is considered “**Abandoned**” when it has not been verified for a period longer than six months. Abandoned workstations shall be clearly marked as a “**NON ESD PROTECTED AREA**” and shall be recertified by Code 300 before use for ESDS work.

**5.2.5** All handling of ESDS parts, assemblies and equipment without ESD-protective covering or packaging shall be within certified ESD protected areas.

**5.2.6** All GSFC facilities at Greenbelt and Wallops where ESDS hardware is handled shall be certified by Code 300. The following requirements shall be reviewed and approved as a condition of certification:

- a. Training certification program;
- b. Records of control program verifications; and
- c. ESD Protected Work Environment.

**5.2.7** Recertification of an ESD protected area is only required if:

- a. Rewiring of the area has occurred;
- b. New work areas are added or moved;
- c. New features are added (e.g. new conductive floor, upgrade to CMSs, etc.);
- d. An abandoned ESD protected area is reactivated; or
- e. An ESD failure is traced to the particular ESD protected Workstation.

**5.2.8** For GSFC facilities at Greenbelt and Wallops, Code 300 is responsible for the initial certification and issuance of the Certification Sticker (See Appendix C) as well as recertifications. Certifications will default to the HBM Class 1A (See Table 5.1) unless specified otherwise.

**5.2.9** Areas and /or workbenches shall be initially certified by Code 300 (for GSFC facilities at Greenbelt & Wallops only) prior to use. This certification shall be maintained by the scheduled inspections for the area/workbench performed by the area ESD program monitor. The area/workstation certification shall be voided if the schedule is violated, the area has been remodeled or the workbenches rearranged (rewired). See paragraph 9.2.2

**5.2.10** Certification shall be validated by the use of certification stickers that shall be applied to all compliant benches, chairs, stools or ESD protected areas (e.g. clean rooms). Equipment such as wrist straps, mats, etc. do not need to have their own sticker or proof of compliance.

**5.2.11** All equipment used to perform an ESD Protected Area Certification shall be in a current state of calibration.

### 5.3 ESD Sensitivity Levels

**5.3.1** The ESD sensitivity of devices is determined using three different models: the Human Body Model, the Machine Model, and the Charge Device Model.

- a. **Human Body Model (HBM).** This simulates the discharge from the fingertip of an operator to an electronic component. In the Human Body Model, a 100-pF capacitor is discharged through a 1500-ohm resistor to ground.

Table 5-1: ESDS Component Sensitivity Classifications – HBM  
(Per ESD STM5.1-2001)

Class	Voltage Range
0	<250 V
1A	250 to <500 V
1B	500 to <1000 V
1C	1000 to < 2000 V
2	2000 to <4000 V
3A	4000 to <8000 V
3B	≥8000 V

- b. **Machine Model (MM).** This originated in Japan as a worst case HBM. In this model, a 200-pF capacitor is discharged directly to ground.

Table 5-2: ESDS Component Sensitivity Classifications – MM  
(Per ESD STM5.2-1999)

Class	Voltage Range
M1	<100 V
M2	100 to <200 V
M3	200 to <400 V
M4	≥400 V



- c. **Charged Device Model (CDM).** This considers the situation where a device is charged and then discharged to ground through one pin or connector. The CDM sensitivity of a given device may be package dependant.

Table 5-3: ESDS Component Sensitivity Classifications – CDM

(per ESD STM5.3.1-1999)

Class	Voltage Range
C1	<125 V
C2	125 to <250 V
C3	250 to <500 V
C4	500 to <1000 V
C5	1000 to <1500 V
C6	1500 to <2000 V
C7	≥2000 V

**5.3.2** Assemblies, components and equipment shall be designed to provide ESD protection for the sensitivity level of the most sensitive ESDS parts chosen for the design. The minimum protection for each ESDS design shall be as specified by the engineering documentation. When no specific sensitivity level is given, the design sensitivity shall default to Class 1A (250 to <500 V HBM) for assemblies, components and equipment. This default limit was chosen to agree with current certification for most of the ESD workbenches at GSFC.

## 5.4 ESD Control Program Requirements

**5.4.1** The supplier shall follow the ESD control procedures detailed in this Manual and verify conformance. As a minimum, the procedures shall include the following ESD control program requirements:

- Conformance of protected areas and items listed in Table 7-1 to requirements set forth in this document. Verify the adequacy of these areas prior to use.
- Use of protective personnel clothing and proper personnel grounding at all necessary points where ESDS items will be handled.
- All personnel handling ESDS items shall have received the necessary training to the appropriate working level (Operator, ESD Program Monitor or Level B Instructor) and shall have a current certification of training.
- Performance of audits and inspections to ensure the integrity of the ESD protected areas and equipment in accordance with the requirements listed in Table 7-1.
- Inspection of documentation for ESD markings, precautions and handling procedures as applicable.
- Proper identification on ESDS items. This can consist of labels, stamps, etc., or in special cases a formal deviation may be granted against this requirement. (See 4.1.2).
- Handling of ESDS items only at approved ESD protected work areas.
- Description of field operations and precautionary procedures, when applicable, to prevent ESD damage.

- i. Maintenance of auditable records and documentation for all measurements required in Table 7-1. These records shall be kept outside the ESD protected area and shall be available to the auditor upon request. When several projects share an ESD protected area, the original records shall be kept at the ESD protected area and copies distributed to each project as needed.
- j. Materials approved for use within ESD protected areas shall be recognized by the ESD Association as ESD-protective materials (the material shall comply with ESD Association recommended practices). Exceptions shall have prior GSFC approval. A record of each material should be kept with other records for ESD stations using it.

## 5.5 Audits and Inspections

**5.5.1 General.** Records of deficiencies, Corrective Actions and Corrective Action Validation & Verification shall be maintained for audits and inspections as described below. These records shall be available at the ESD area. Form and format of the records of deficiencies shall be coordinated through the GSFC Audit Coordinator.

**5.5.2 Audits.** The applicable SAM or designee shall be responsible for the ESD areas under their accountability. Special audits may be conducted by Code 300. The audit shall be based on the requirements of this manual and shall be coordinated through the GSFC Audit Coordinator. ESD protected areas shall be audited at least once a year to remain active.

**5.5.3 Inspections.** Inspections are the responsibility of the area ESD program monitors. The inspections shall consist of a general review of the area and records as well as verification to be performed in accordance with Appendix A. These inspections may be carried out any time the ESD program monitor deems them necessary to ensure continuous compliance with the requirements of this manual. However, as a minimum, they shall be performed every time the verification tests in paragraph 7.1.4c are required.

**5.5.4 New Programs.** If a new GSFC Program takes over the ESD protected area and the old records are not available, the ESD program monitor shall perform a reverification in accordance with Appendix A and attach new stickers to the applicable workstations.

## 6 TRAINING AND CERTIFICATION PROGRAM

### 6.1 General

**6.1.1** The supplier shall ensure that all personnel who perform or supervise any of the following functions have current certifications for either ESD training to this Manual or equivalent ANSI/ESD S20.20–1999 based system, and is familiar with the requirements of this document and any additional hardware-specific requirements.

- a. Design,
- b. Production,
- c. Inspection and test,
- d. Procurement (*Certification is required only if handling, purchasing or specifying ESDS materials*),
- e. Storage, shipping and receiving,
- f. Handling, and/or
- g. Installation, maintenance and repair.

Evidence of training certification status shall be available in the work area.

### 6.2 Training Program

**6.2.1** GSFC administers a training program that meets the requirements of this Manual and complies with ANSI/ESD S20.20–1999. This training is available at the NMTTC Eastern Region Training Center at <http://workmanship.nasa.gov/index.jsp> . Select “Workmanship Training” and then “GSFC School.”

**6.2.2** Alternatively, suppliers may train in-house personnel for certification or recertification utilizing a training program taught by a currently certified Level B instructor. See paragraph 6.3.3. The supplier training program documentation shall be available for review and shall be submitted to GSFC upon request. To assist with documentation, a generic Training Plan is given to the Level B instructors. Other training information may be obtained from the NMTTC site given in 6.2.1.

**6.2.3** The documentation shall describe training and certification of training that satisfies the requirements herein. This documentation shall include, but not be limited to, the following, as applicable:

- a. Procedures for training,
- b. Lesson plan(s)/student manuals,
- c. Hours of instruction,
- d. Procedures for certification and recertification,
- e. Procedures for recording of training, recertification and methods of identifying/recalling trained personnel, and
- f. Criteria for Certification of Training.

### 6.3 Certification of Training Levels

**6.3.1** There are four training levels under this program: Level A Instructor, Level B Instructor, ESD Program Monitor, and Operator. Level B instructors, ESD program monitors, and operators shall be tested to ascertain comprehension of the material covered for each level.

**6.3.2 Instructor Level A.** Level A NASA instructors are certified by the NASA Training and Certification Board. Level A NASA instructors have the authority to train Level B instructors, ESD program monitors, and operators.

**6.3.3 Instructor Level B.** This training is for those who may be called upon to train ESD program monitors and operators to work in ESD controlled areas.

- a. Level B instructors have the authority to train operators & ESD program monitors who work for their employer or sub-tier contractors to their employers.
- b. Training of Level B instructors shall be provided by a Level A instructor at the NMTTC.
- c. The training shall encompass the following as a minimum:
  - (1) ESD Control Program (as described in this manual);
  - (2) Principles/control methods of static electricity;
  - (3) Identification of ESDS items;
  - (4) Protective materials and equipment;
  - (5) Protected areas and workstations;
  - (6) Handling of ESDS items;
  - (7) Packaging, marking and shipping of ESDS items;
  - (8) Performance of ESD audits;
  - (9) Administration and record keeping;
  - (10) Class preparation, presentation and test administration; and
  - (11) Demonstration of ability to teach a class.

**6.3.4 ESD Program Monitor.** This training is for those who play a major role in ESD damage prevention. Training of ESD program monitors shall encompass the following as a minimum:

- a. ESD Control Program (as described in this manual);
- b. Principles/control methods of static electricity;
- c. Identification of ESDS items;
- d. Protective materials and equipment;
- e. Protected areas and workstations;
- f. Handling of ESDS items;
- g. Packaging, marking and shipping of ESDS items;
- h. Performance of ESD audits; and
- i. Administration and record keeping.

**6.3.5 Operator Level.** This training is intended for technical personnel performing work on or with ESDS items, such as assembly, soldering, conformal coating, cleaning, inspections, testing, packaging, and shipping. It is also intended for any other personnel dealing with ESDS material. The training shall encompass the following subject areas as a minimum:

- a. ESD Control Program (contents of this manual);
- b. Principles/control methods of static electricity;
- c. Identification of ESDS items;
- d. Protective materials and equipment;
- e. Protected areas and workstations;
- f. Handling of ESDS items; and
- g. Packaging, marking and shipping of ESDS items.

## **6.4 Record Maintenance.**

**6.4.1** Records of training shall be retained for a minimum of 5 years or as required by contract. The records on file shall consist of the following information as a minimum:

- a. Standard & Control Plan used for the training;
- b. Name of the trainee;
- c. Name of the organization which employs the trainee;
- d. Level of training completed;
- e. Date of completion of training;
- f. Name of the instructor and organization providing the training;
- g. Traceability number of the certificate; and
- h. Test Score.

**6.4.2** The Certificate of Completion of Training document shall contain as a minimum the information described above, except for the test score. See example in Appendix C.

**6.4.3** Evidence of Certification of Training status shall be available from the work area.

**6.4.4** The training organization shall issue a wallet card version of the certificate for auditing purposes.

**6.4.5** It is the supplier's responsibility to certify the competence of their Level B instructors, ESD program monitors and operators. Certification of Competence requires a current Certificate of Completion of Training.

## **6.5 Maintenance of Certification of Training Status**

**6.5.1** Maintenance of training certification for ESD program monitors, Level B instructors and operators requires periodic retraining and recertification.

**6.5.2** Recertification shall be required when:

- a. New ESD control techniques have been approved that require different skills;
- b. Two years have elapsed since last certification;
- c. Job performance indicates inadequate understanding of ESD controls;
- d. The Certificate of Completion of Training is not available at the NMTTC or the supplier; and/or
- e. The supplier is not willing to issue Certification of Competence based on another supplier's training program.

**6.5.3** The Certification of Training is completely portable as long as the employee can produce objective evidence of a current Certificate of Completion of Training.

**6.5.4** The portability of Certification of Competence is at the discretion of the employer.

## **7 ESD CONTROL REQUIREMENTS FOR FACILITIES**

### **7.1 General**

**7.1.1** This section contains requirements specific to ESD protected facilities including work areas, equipment, tools and materials.

**7.1.2** The effectiveness of ESD protection in eliminating and/or dissipating electrostatic charges shall be demonstrated by inspection of facilities in accordance with the requirements in Table 7-1 and specific requirements found throughout this section.

**7.1.3** All ESD protected areas are certified to HBM Class 1A. When handling parts sensitive to lower than 250 volts, the area shall be certified to Class 0 with additional protection if required. Proper implementation of this protection shall be verified by the ESD program monitor prior to commencement of work in these areas. No specific Identification Level is required for Class 1A areas. Where a different level classification is required the area shall be clearly marked with the proper classification symbol.

**7.1.4** The required measurements of Table 7-1 are performed as follows:

- a. Operators at the ESD protected area shall perform tests # 5, 7, 8(continuous), 11 & 13 as they apply to their area. For an example of the Test Log see appendix D.
- b. The ESD program monitor for the area is responsible for ensuring that the logs are up-to-date.
- c. The area ESD program monitor is also responsible for verification of tests # 1, 2, 3, 4, 6, 8(annual), 9, 10, 11 & 12. See example of the ESD Protected Area Test Log, Appendix B.
- d. Not all tests in Table 7-1 may be performed during recertification, at the option of the certifier, but he/she shall sign the sticker and fill out the ESD Protected Area Test Log (Appendix B) for the tests performed or confirmed by log examination.

### **7.2 Compliance**

All items that are not in compliance with Table 7-1 shall be refurbished or replaced and/or rendered unusable and clearly marked as unacceptable, until corrective actions are completed. See Appendix C for a Failed Area sign.

### **7.3 Traceability**

All items listed in Table 7-1 shall require the maintenance of “on-the-premises” records for verification prior to use. The ESD program monitor shall maintain an archive of those records for a period of no less than 5 years or as required by the specific contract.

Table 7-1: ESD Control Program Verification Schedule and Required Measurements

Test #	ITEM	Para. Ref.	Test Parameters	Verification Intervals <sup>4</sup>				
				Continuous	Daily	Weekly	Monthly	Annual
1	<sup>2</sup> Work Surface Resistance	7.7.2A5.2.1	$< 10^9 \Omega$ Between two points 10" apart on the Work Surface.				X	
2	Work Surface Grounding	7.7.6 A5.2.2	$10^6$ to $10^9 \Omega$ from the center of the work surface to the equipment ground or $< 1$ ohm with GFCI.				X	
3	<sup>1,2</sup> Protective Floor Resistance	7.8.2 7.8.4 A5.2.3	$< 10^9 \Omega$ . After cleaning the floor shall be checked and the data recorded. See restrictions on paragraph 7.8.2				X	
4	<sup>1,2</sup> Protective Floor Grounding	7.8.2 A5.2.4	$10^6$ to $10^9 \Omega$ from the floor surface to the equipment ground or $< 1$ ohm with GFCI.				X	
5	<sup>3</sup> Wrist Strap Check	7.9.2 7.10.4	Use approved Wrist Strap checker and log daily. The use of CMSs is preferred.		X			
6	Wrist Strap Ground Point Resistance	7.9.2d A5.2.5	$< 1.0$ -ohm impedance from Groundable Point (Gp) to the Equipment Ground. ( $< 1.2 \times 10^6$ ohms if measured through a Continuous Monitoring System).				X	
7	<sup>3</sup> Foot Grounding Device Integrity	7.9.3 7.10.3	$< 35 \times 10^6 \Omega$ or use approved (calibrated) footwear checker & log each time you reenter the area.		X			
8	<sup>2</sup> ESD Continuous Monitoring System	7.10.4 A5.2.6	Verify functionality before handling ESDS items. Check alarm limits per Mfr. Instructions.	X				X
9	<sup>2</sup> Stool / Chair Ground.	7.11.2.a A5.2.7	$> 10^5$ to $< 10^9$ ohms to the chair's groundable point. [For Class 0 Work only, verify monthly].				[X]	X
10	<sup>2</sup> Mobile Equipment	7.11.3	$< 1$ ohm if tied directly to equipment ground. $< 10^9$ when grounded thru conductive flooring, referenced to CPG.					X
11	Humidity (RH)	7.12.1 A5.2.8	30 to 70% RH continuous for work area. Verify log monthly. For Class 0 Work Area certification areas RH shall be $> 40\%$ .	X			X	
12	<sup>2</sup> Ionizers	7.13.1 Table 7-2 A5.2.9	Decay $< 45$ sec. ( from $\pm 1000$ V to $\pm 100$ V ) Balance shall be $\pm 100$ V for Class 1A and above. Balance shall be $\pm 50$ V for Class 0.				X	
13	Soldering Iron Tip to Ground Resistance	7.14.4 A5.2.10	Soldering Stations with self-contained checkers shall use them per schedule. Otherwise check to $< 20$ ohms and $< 2.0$ mvAC. Log.			X		
<sup>1</sup> Additionally, the Protective Floors resistance shall be checked and documented <i>at least</i> 2 hours after the floor has been cleaned but before the room is used. The area does not need to be checked after Vacuuming. <sup>2</sup> These items require proof of verification. (i.e. sticker or log entry) <sup>3</sup> Automatic data loggers may be used for wrist strap and foot grounding daily checks. <sup>4</sup> Any changes to verification Intervals shall be approved by deviation request. (See 4.1.2).								



## **7.4 Identification and Access - ESD Areas**

The ESD-protected area, where ESDS items are to be processed, shall be clearly identified by prominently placed signs. Access to such areas shall be limited to trained and equipped personnel. A partition, rope guard, or similar means shall be set up to assist in prohibiting unauthorized and untrained personnel from entering the ESD-protected area. All other personnel shall be escorted and equipped with standard protective clothing, as required.

## **7.5 Temporary Use of ESD benches for Non ESDS Work.**

**7.5.1** ESD protected areas may be used to perform non-ESDS work when approved by the ESD program monitor and under the following circumstances:

- a. The area shall be clearly marked as a “Non-ESD Protected Area” during the period it is used for non-ESDS work.
- b. The ESD program monitor shall inspect and approve the ESD protected area before ESDS items are again handled in that area.

**7.5.2** ESD workstations designated as Class 0 or higher sensitivity **shall not be used for Non-ESDS work**. If any of these areas are used for non-allowed material handling, the workbench shall be recertified by Code 300 before the area can be used to handle ESDS parts.

## **7.6 Prohibited Materials and Activities**

**7.6.1** The area shall be maintained in a clean and orderly condition.

**7.6.2** Smoking, eating and drinking in ESD protected areas shall not be permitted.

**7.6.3** Materials unessential to the fabrication area are also prohibited in the ESD protected area.

**7.6.4** Clipboards, books, notebooks, loose sheets of paper, etc used to read or record data or follow instructions (this manual included) shall be kept at least 1 meter (3.3 ft.) from ESDS items or placed in ESD safe bags or totes. Materials specifically made and verified to be safe in an ESD area are exempt from this requirement.

**7.6.5** “Tacky Mats” usually used at the entrance to Clean rooms, CRT displays, and other equipment which generates static charge shall be outside the ESD protected area or placed at least 1 meter away from where ESDS parts are handled.



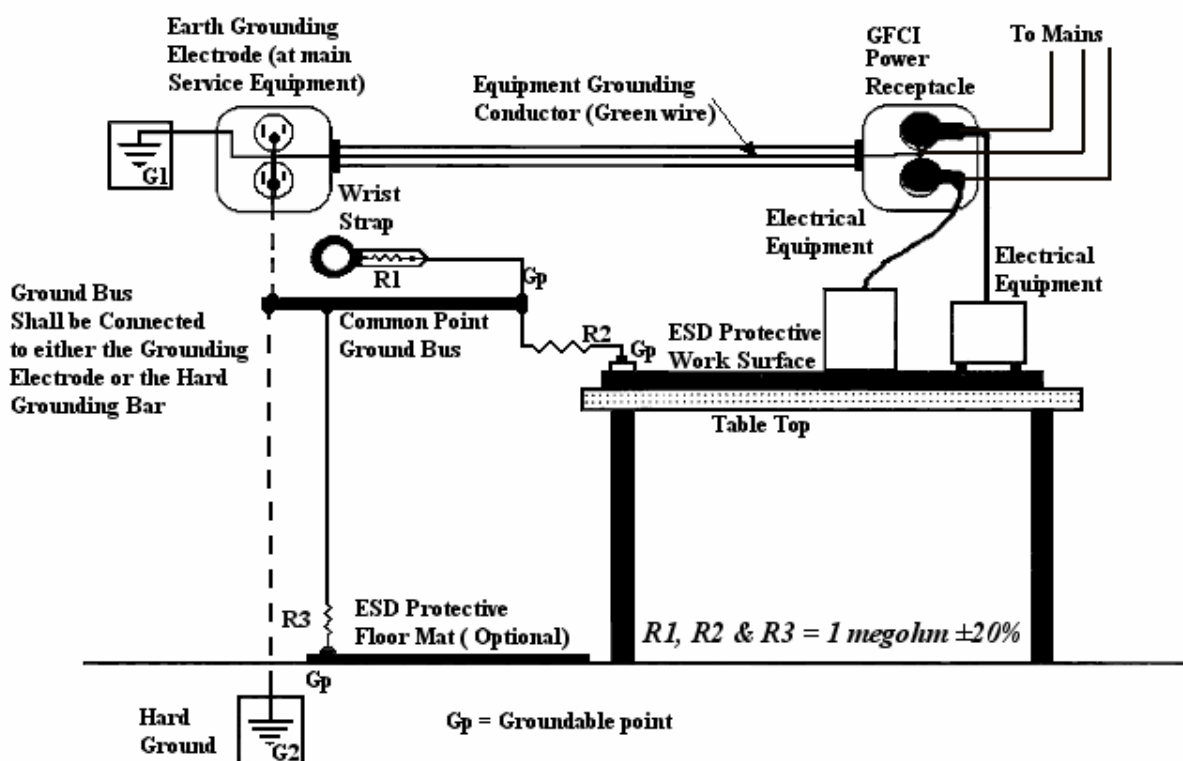


Figure 7-1: Typical ESD Grounded Workbenches

## 7.7 ESD-Protective Work Surfaces

**7.7.1** All work surfaces in an ESD-protected area shall be conductive or static dissipative ( $>10^5$  to  $<10^9$  ohms for surface resistance) and electrically connected to the common point ground (R2 is optional to provide a soft ground when highly conductive work surfaces are needed). See Figure 7-1 above.

**NOTE:** WORK SURFACES SHOULD BE SOFT GROUNDED TO ELIMINATE THE SAFETY HAZARD OF TOUCHING A HIGH VOLTAGE CIRCUIT WITH ONE HAND AND A HARD GROUND WITH THE OTHER. A CONDUCTIVE WORK SURFACE WHICH IS CONNECTED TO HARD GROUND REQUIRES THAT THE ELECTRICAL POWER LINE BE PROTECTED WITH A GROUND FAULT CIRCUIT INTERRUPTER.

**7.7.2 Surface Resistance.** For testing purposes, the resistance of surface material shall be  $< 10^9$  ohms. (Reference ESD TR20.20-2000 paragraphs 5.3.1.7.1 & 5.1.5).

**7.7.3** The protective work surface shall be sufficiently large to accommodate the resting of common hand tools on the protective surface rather than on adjacent non-protected surfaces.

**7.7.4** The protective work surface shall not release particle contaminants and shall resist attack by common solvents or cleaners (See paragraph 7.17 Cleaning and Cleaning Agents).

**7.7.5 Work Surface Grounding.** Soft grounding (see definitions paragraph 3.1) of dissipative work surfaces shall measure  $<1.2 \times 10^6$  ohms. When highly conductive work surfaces (e.g., stainless steel or copper) are used, and they need to be connected directly to the equipment or auxiliary ground without the R2 resistor (see Figure 7-1), Ground Fault Circuit Interrupters (GFCIs) shall be used in the ESD protected workbench. Type "A" GFCIs are preferred. Ref. ESD TR20.20 – 2000 Handbook, Page 43, Note 1. GFCIs shall be tested at least once a month, using their self-test feature. See appendix A paragraph A5.2A5.2.1b. The GFCI manufacturer web site usually has the best method to check their particular model.

**7.7.6 Resistance from Work surface.** The resistance measurement from the center of the work surface to the equipment ground shall be  $< 10^9 \Omega$ . Ref. ESD TR20.20 – 2000 Handbook Paragraph 5.3.1.7.1

## **7.8 ESD-Protective Floor Coverings**

**7.8.1** Conductive floors and/or grounded conductive floor mats are mandatory in areas where personnel are not wearing wrist straps. Under these conditions, the use of leg straps, heel straps or conductive shoes is mandatory. See paragraph 7.9.3 (Foot Grounding Devices).

**7.8.2 Protective Floor Resistance.** ESD protective flooring shall be connected directly to equipment or auxiliary ground without R3 (R3 is optional); see Figure 7-1. For testing purposes, the dissipative floor to system ground resistance shall be between  $10^6$  and  $10^9$  ohms. ESD TR20.20-2000 paragraph 5.3.4.8.1.1 recommends  $10^6$  to  $10^9$  ohms for floor resistance for safety reasons. On highly conductive floors the options to include R3 (see Fig 7-1) or use of GFCIs is available. Measure the floor resistance between the equipment ground and a point on the floor at least 12 inches away from the floor-to-ground connection, and log the result.

**7.8.3** Conductive floors or mats shall be kept free of dust, dirt and other contaminants.

**7.8.4** After each cleaning, conductive floor resistance shall be verified per paragraph 7.8.2 above and the results shall be recorded. Vacuuming or dry sweeping the floor does not require a subsequent check.

**7.8.5** The use of conductive waxes shall be in accordance with manufacturer recommendations. Floor resistance shall be verified after application. The check shall be done in accordance with supplier's ESD program documentation and the results shall be recorded.

**NOTE:** *Some conductive waxes may be a source of contaminants. Make sure the type used has been approved for use around flight hardware.*

**7.8.6** Conductive waxes on non-conductive floors shall not be considered an effective method of ESD control.

**7.8.7** Use of carpeting in an ESD-protected area shall be prohibited. This includes carpeting advertised as "conductive" or "static-eliminating."

## 7.9 Personal Grounding Devices

**7.9.1** Personal grounding devices shall be supplied to all personnel working with or handling ESDS items to prevent the accumulation of dangerous electrostatic charge levels. All personnel coming within 1 meter (3.3 feet) of any ESDS item shall wear a grounding device.

**7.9.2 Wrist Strap.** The wrist strap is the preferred means for ESD protection; it is the “first line of defense.” Checking of wrist straps shall be done in accordance with paragraph 7.10.2.

The wrist strap system consists of four major components:

- a. **Lead.** Only the lead supplied with the wrist strap shall be used, as it may contain the safety resistor.
- b. **Cuff.** The design of the wrist strap cuff shall ensure conductive contact with the wearer’s skin. Metallic cuffs are preferred over plastics or fabric cuffs. Bead type chains are prohibited. The wrist strap shall have a cuff connector, which breaks away with a force between 1 and 5 pounds per ESD S1.1. This property shall be tested each time a new manufacturer or type of wrist strap is approved for use.
- c. **Safety Resistor.** All wrist strap systems shall contain an integral current-limiting safety resistor (1 megohm  $\pm$  20%). This resistor may be an integral part of the lead.
- d. **Ground Termination.** The wrist strap ground termination shall ensure a positive and durable connection between the lead and the equipment ground. For testing purposes the resistance between Gp and the equipment ground shall be  $<1.0$  ohm. For wrist straps protected through a CMS, the value shall be  $<1.2 \times 10^6$  ohms.

**7.9.3 Foot Grounding.** Foot grounding devices such as leg, toe or heel straps, or conductive shoes worn in conjunction with a conductive floor and/or conductive floor mats, are acceptable alternatives to a wrist strap in those situations where the operator needs to be mobile and the use of a wrist strap is impractical or unsafe. Foot grounding devices shall be worn on both feet and shall not be worn outside the ESD protected area. The total resistance of these devices shall be  $< 35 \times 10^6$  ohms. Use an approved footwear checker and log every time the operator enters the ESD protected area. Ref. ESD TR20.20-2000 paragraph 5.2.3

***NOTE: FOOT GROUNDING DEVICES SHOULD BE KEPT CLEAN SO THAT CONTAMINANTS DO NOT INHIBIT THEIR CONDUCTIVE INTERFACE WITH THE FLOOR.***

## 7.10 Integrity Testing of Personal Grounding Devices

**7.10.1** The integrity of the connection between the operator, the personal grounding device and the ground connection is critical to proper ESD protection. All personal grounding devices shall be periodically checked for signs of damage or wear, and replaced when needed.

**7.10.2** Wrist straps shall be either continuously monitored or checked each time the wearer enters the ESD protected area (use an approved wrist strap tester). The first daily check shall be logged. Logging wrist strap checks is not required for areas that use Continuous Monitoring Systems (CMS) throughout the ESD protected area. If CMS is used at a workbench, all non-monitored wrist strap connections shall be disabled.

**7.10.3** Foot grounding devices shall be checked and logged each time the wearer enters the ESD protected area. Foot grounding devices shall be worn on both feet and shall be checked one foot at a time.

**7.10.4** Workstation Real Time Continuous Monitors eliminate the need for users to test wrist straps and log the results. Personnel shall check Continuous Monitoring Devices to ensure functionality just before handling ESDS items. (The monitor's alarm should sound and the appropriate red light should light when the lead is temporarily removed from the cuff. See Para. A5.2.6). These units shall be verified operational (within specification) annually or when a malfunction is encountered.

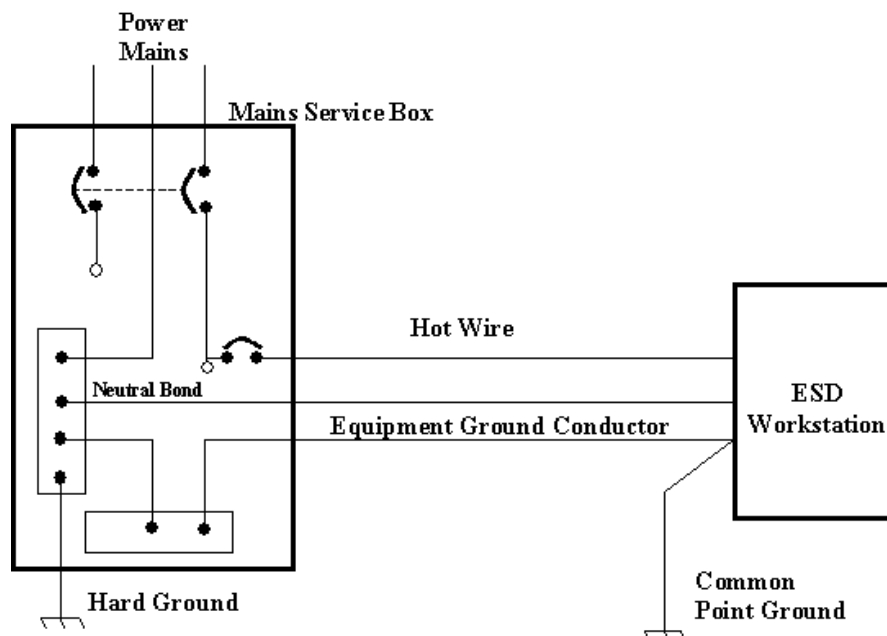
**7.10.5** If a check fails, corrective action shall be taken before work is performed and a subsequent re-check shall pass before work resumes. Appropriate corrective actions include:

- a. Replace cord;
- b. Replace complete system;
- c. Use a conductive lotion designed for use with ESD wrist straps (if acceptable in the area of use); and/or
- d. Wrist band cleaning.

If flight hardware has been handled while wearing a failed personal grounding device, a risk assessment of hardware failure shall be performed and the event shall be recorded.

## 7.11 Equipment and Facilities

**7.11.1 Facilities Grounding.** The preferred practice is to use the third wire AC line ground for grounding all items at the ESD-protected Area. When a separate grounding line is present or used in addition to the equipment ground, it should be electrically bonded to the equipment ground at each ESD protected work station to minimize the difference in potential. The resistance of the conductor from the common point ground to the equipment ground (AC ground) should be less than 1 ohm. The impedance from the area common point ground to the neutral bond at the main service box should be less than 2 ohms. See Figure 7-2. Daisy-chaining is not permitted.



**Figure 7-2: Main Service Box**

### 7.11.2 Stool and Chairs.

- a. **Certification.** Where chairs and stools are required, they shall carry a certification sticker. The resistance for any part of the chair to a groundable point shall be between  $10^5$  to  $10^9$  ohms per ESD STM12.1-1997. For Class 0 work, the chairs and stools shall be verified periodically. See Table 7-1 for verification intervals.
- b. **Grounding.** For handling Class 0 sensitive items a positive electrical contact between the Common Point Ground and the chair or stool is required. This contact may be achieved through an ESD protective floor or ESD protective floor mat.

**7.11.3 Mobile Equipment.** Where carts, wagons or trams are required to be grounded, and approved conductive floors are utilized, positive electrical contact shall be made between the floor and conductive structure of the cart, wagon or tram. For testing purposes the resistance from the equipment to the Common Point Ground shall be  $< 10^9$  ohms. If the floor is non-conductive, the vehicle shall be grounded before ESDS items are loaded or removed from the vehicle. Flight hardware shall be protected with ESD wrap, totes or other approved method. Consult the area ESD program monitor for the approved solution for the project involved.

## 7.12 Humidity

**7.12.1** The relative humidity (RH) shall be maintained in ESD-protected work areas at 30% to 70%. At levels below 30%, additional precautions shall be employed, such as turning on a humidifier to achieve the required humidity or using an air ionizer. If additional precautionary methods are not available, work shall be halted until the required humidity level is obtained. For handling Class 0 sensitive parts the relative humidity shall be between 40% and 70% (Best Industrial Practice).

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**7.12.2** A check of the RH level in each ESDS area shall be performed at the start of the workday and the result shall be logged. Periodic observations of the RH level should be made to ensure continuous compliance. If the RH level is close to 30% or is seen to be dropping rapidly, extra vigilance is recommended. Data loggers with an integral alarm system may dispense with the daily check.

**7.12.3** The records of continuous RH monitoring (chart recorders, data loggers) shall be retained for 5 years or as required by contract.

**NOTE: SURFACE RESISTIVITY CHANGES EXPONENTIALLY WITH HUMIDITY CHANGES. THEREFORE, RELATIVE HUMIDITY LEVELS MAINTAINED BETWEEN 40% AND 60% ARE RECOMMENDED.**

### **7.13 Air Ionizers**

**7.13.1** Air ionization is a technique to neutralize charges on insulators and ungrounded conductors. Air Ionizers shall be used when handling Class 0 sensitive parts or when the relative humidity falls below 30% in the work area. See Table 7-2.

**7.13.2** Unrestricted airflow between ionizer and the ESDS item is required for the ionizer to be effective. Sufficient distance between the ionizer and the ESDS items shall be maintained to ensure proper ion balance in the airflow. Consult the ionizer manufacturer.

**7.13.3** Careful selection of the ionizer is needed to meet these requirements (see manufacturer's data sheet). Selection may also be application dependent. Ionizers shall be routinely maintained and tested in accordance with manufacturer's recommendations.

**7.13.4** Electrostatic survey meters shall be used to verify the effectiveness of ionizers in extremely sensitive work areas (Class 0, Class M1) before work is started.

**CAUTION: An improperly adjusted air ionizer can actually charge ESDS devices and lead to possible damage to the device. Only calibrated air ionization systems shall be used.**

Table 7-2: ESD Sensitivity for Selection and Performance of Air Ionizers

<b>Class</b>	<b>ESD Sensitivity</b>	<b>Air Ionization</b>	<b>Discharge time</b>	<b>Float Potential</b>
1A +	≥250 volts	Optional	± 1000 to < ± 100 V in < 45 sec.	< ± 100 V
0*	>100 V to < 250 V	Required	± 1000 to < ± 50 V in < 20 sec.	< ± 50 V
M1**	<100 volts	Required	± 1000 to < ± 20 V in < 20 sec.	< ± 20 V

\* Class 0 covers all HBM <250 V but it is not sensitive enough to protect some newer parts.

\*\* This level is intended for use with automatic equipment therefore it uses MM vs. HBM

**CAUTION: THE USE OF ANY TYPE OF AIR IONIZER IS PROHIBITED IN THE PRESENCE OF "POWERED-UP" HIGH-VOLTAGE OR RF SENSITIVE EQUIPMENT TO AVOID BREAKDOWN IN THE PRESENCE OF IONIZED AIR. ALSO KEEP FLAMMABLES AWAY FROM AIR IONIZER SINCE CORONA DISCHARGE COULD CREATE A FIRE HAZARD.**

## **7.14 Hand Tools, Equipment, and Fixtures**

**7.14.1** Tools designed for ESD areas, such as static dissipative cushioned tools or uninsulated metal hand tools such as pliers, cutters, tweezers and wire strippers, are preferred in ESD-protected areas.

**7.14.2** Hand tools shall be kept on the grounded work surface when not in use.

**7.14.3** Only antistatic solder extractors made of metal, or having a metallized plastic barrel and tip, shall be used in an ESD-protected area.

**7.14.4** Electrical tools used in ESD-protected areas shall have a three-wire grounded power cord. Any “double insulated” tool used shall have static dissipative handle grips and be approved for use in those areas. The area making contact with the work piece shall be grounded (e.g., soldering iron tip). When measured from the work piece contact point to ground, the resistance shall be less than 20 ohms and the potential difference shall not exceed 2 millivolts RMS using methods indicated in the supplier’s process documentation. See Appendix A paragraph A5.2.10. Some soldering stations have an integral GFCI which will trip the unit if the tip is not grounded. These units are considered Continuous Monitoring Systems (CMS) and are exempt from the logging requirements of Table 7-1, but the proper operation of the system shall be periodically checked depending on the usage. See Table 7-1 Test # 2.

**7.14.5** Some Digital Multimeters (DMMs) introduce voltage spikes when changing scales and/or have high voltages when measuring resistance. Make sure that the measuring equipment is compatible with the hardware being measured. Measuring equipment, breakout boxes, harnesses, etc. shall be properly discharged (grounded) before making connection to flight hardware. If in doubt, consult with the designer of the hardware if the equipment you are using can cause damage to their hardware.

**7.14.6** Fixtures used while working at an ESD protected area shall be ESD safe and grounded through the ESD protective work surface.

## **7.15 Protective Packaging**

**7.15.1** Electrostatic protective packaging requires both the prevention of charge generation (e.g., triboelectric contact and separation) and protection from external electrostatic fields. The surface resistance of any static dissipative material shall be  $\geq 10^4$  &  $< 10^{11}$  ohms (Reference ANSI/ESD S541-2003).

**7.15.2** Protective bags and packaging are considered ESD protective based on the following application methods:

- a. Materials used in protective bags and pouches shall satisfy the resistance requirements to avoid triboelectric charge buildup.
- b. Bags and pouches used for electrostatic shielding shall be constructed from a single folded piece of material. Two-piece construction is prohibited. If bags or pouches are not transparent to allow identification of contents without removal, a label stating contents shall be placed on the outside of the bag or pouch.
- c. All integrated circuits used by GSFC should be received packaged in non-metallic conductive and static dissipative magazines, chutes and dip tubes. Parts not received in compliant packaging shall not be handled and shall be rejected as non-compliant.



- d. Neither static dissipative impregnated nor topically treated plastics provide electrostatic shielding. Both types shall be enclosed in an outer container, which will provide such protection during shipping. For electric field shielding, the package shall be electrically conductive and have a surface resistance of  $< 10^4$  ohms.
- e. Tote boxes shall be made of conductive or static dissipative material. All tote boxes shall be fitted with covers of the same conductivity as the bottom sections. The fit of this cover shall be such as to ensure the conductivity across this interface.

## **7.16 Temperature Chambers and Cooling Agents**

**7.16.1** Gas flow can be a significant generator of electrostatic charges. Precautions shall be taken when gas flow is utilized in the area of ESDS items.

**7.16.2** Cold chambers shall have the conductive baffles and shelves within the chamber grounded. The ESDS items shall be contained within or mounted on conductive material.

**7.16.3** When pressurized cryogenic cooling agents are used for localized cooling, as in troubleshooting, they shall be electrostatically safe.

**7.16.4** The stability of ESD-protective materials which are used in temperature chambers should be suitable for the test temperature and humidity ranges.

**7.16.5** Resistance checks shall be sufficient for normal test chamber environments. For extremely sensitive parts the use of electrostatic survey meters may be required (see paragraph 7.18). Survey meters can provide information on stray fields harmful to the hardware being tested. Consult the meter manufacturer's documentation for additional cautions.

## **7.17 Cleaning and Cleaning Agents**

**7.17.1** Cleaning agents and methods used on ESD-protective items (e.g., work surfaces and floor coverings) shall not reduce the effectiveness of these items and shall not cause leaching or leave insulating residues.

**7.17.2** In addition to other required properties (e.g. solvency), cleaning agents used on ESDS items shall be chosen for low electrostatic charging propensity and shall be approved for use in flight hardware.

**7.17.3** Only natural bristle or static dissipative brush materials shall be used for cleaning ESDS items.

## **7.18 Electrostatic Survey Meters, Voltmeters and Monitors**

**7.18.1** Electrostatic survey meters shall be used to detect the presence of electrostatic charges, and shall be of the type which read the electrostatic charge on a surface area without requiring contact. Such instruments shall be capable of measuring the voltage on a sample not more than 8 inches in diameter with a minimum resolution of 100 volts and a range of at least 1 kilovolt (kv). For areas handling highly sensitive parts, other methods may be needed. Always follow the manufacturer's recommendations.

**7.18.2** The use of electrostatic monitors designed to actuate an alarm when an electrostatic field reaches a preset level is recommended in an ESD-protected area.



**7.18.3** A wrist strap tester shall be available in all areas where ESDS items are handled, unless the ESD protective area exclusively uses a Continuous Monitoring System.

## **7.19 Clothing Requirements**

**7.19.1** Static dissipative outer garments (smocks) shall be worn in ESD protected areas. The smocks shall cover all personal garments above the wrist except at the neck area and make intimate contact with the skin. Smocks shall be fully zipped/buttoned all the time they are worn.

**7.19.2** The garments shall be properly checked after laundering (Reference ESD STM2.1). This requirement may be met by using an approved cleaning facility for ESD garments.

**7.19.3** When handling ESD Class 0 sensitive parts, the ESD smock shall be connected to the common point ground or wrist strap lead; otherwise it becomes an isolated ungrounded conductor. Some garments have the provision for attachment to the wrist strap coil cord snap. Some configurations also allow for continuous monitoring. For less sensitive areas (Class 1A and above), smocks may be used over cotton shirts or short-sleeved shirts without the extra ground connection. This configuration permits slow static dissipation of the charge acquired by the garment.

**7.19.4** Finger cots and gloves, when worn in an ESD-protected area, shall be made of static dissipative materials.

## **7.20 Tailoring**

The owning organization shall submit a proposed summary design plan to Code 300 for approval in accordance with Section 4.1.2 Tailoring decisions, including rationale, shall be documented and approved by Code 300.

Where the Human Body Model (HBM) does not provide sufficient protection for the hardware, the Machine Model (MM) or the Charge Device Model (CDM) should be considered when designing the ESD protected area.

## 8 OPERATING REQUIREMENTS

### 8.1 Requirements for Handling ESDS Items

**8.1.1** ESDS items shall be handled only in an ESD protected area. When outside ESD protected areas, ESDS items shall be completely enclosed inside ESD-protective packaging.

**8.1.2** Paperwork accompanying an ESDS item (e.g., QA records, routings, instructions) shall be contained in static dissipative bags or envelopes. This paperwork shall not come in physical contact with an ESDS item. Materials specifically made and verified to be safe in an ESD area are exempt from this requirement

**8.1.3** Shunts, such as bars, clips, or conductive coverings, shall be used to protect an ESDS item when it is not being tested or worked on. Process-essential insulators (e.g. Kapton tape) shall be neutralized with an ionizer before they can be moved within 12 inches of ESDS items.

**8.1.4** All containers, tools, test equipment, and fixtures used in ESD protected areas shall be grounded before and during use. A common soft ground shall be established between an ESDS item and any test equipment before connecting or disconnecting test cables.

**8.1.5** Personnel handling ESDS items shall avoid physical activities that produce static charges (e.g., wiping feet, or adding or removing items of clothing) while in the vicinity of ESDS items.

### 8.2 Special Requirements for Highly Sensitive Items

**8.2.1** The requirements for handling Class 0 or higher sensitive parts are found elsewhere in this document. They are provided here as a guide to the ESD program monitors.

**8.2.2** Especially sensitive areas shall implement the following requirements:

- a. Chairs & stools shall be grounded and periodically verified as ESD protective. See Table 7-1 for intervals.
- b. Relative Humidity shall be kept over 40%, and it shall be monitored and recorded just before work is started.
- c. Ionizers shall be in place and working properly. See Table 7-2. It is recommended that an ESD survey meter be used to check the area before work is begun.

**CAUTION:** *An improperly adjusted air ionizer can actually charge ESDS devices and lead to possible damage to the device. Only calibrated air ionization systems shall be used.*

- d. Smocks shall be grounded to the Common Point Ground or through the wrist strap. This is an exception to the daisy chain rule (See Para. 7.11.1). However, this grounding must not interfere with the operation of the CMS if one is used.
- e. Cables and harnesses shall be discharged to ground through an approved method prior to mating and demating to ESD sensitive assemblies.
- f. Soldering irons, if used, shall have a continuous monitoring circuit to protect the hardware.

### **8.3 Receiving, Internal Handling, and Shipping**

**8.3.1** The following requirements shall apply during receipt, internal handling, and shipping:

- a. All ESDS items received shall be examined for proper ESDS precautionary marking and ESD-protective packaging. See paragraph 8.6.
- b. Inadequate precautionary markings shall be corrected prior to further processing.
- c. When an item is received that has not been protected during shipment or internal transfer, it shall be rejected as defective and processed as non-conforming material. The package shall be labeled as failed ESDS material and reported per GPR 5340.2.
- d. When a kit is assembled that includes an ESDS item, the entire kit shall be packaged and marked as ESDS. Accompanying documentation shall identify the kit.
- e. ESDS items packaged for shipping shall be packaged and marked as required by the contract in addition to the requirements of this publication.

### **8.4 Equipment Level Test and Maintenance**

**8.4.1** The following requirements are applicable, both within a facility and in the field, when the equipment being serviced contains ESDS items:

- a. Personnel shall be properly grounded (e.g. using a wrist strap) before each maintenance action. Maintenance actions include adjustments, restoring covers, and tightening fasteners.
- b. Protective packaging of a replacement ESDS item shall be grounded to the equipment to dissipate any static charge before the package is opened.
- c. As an ESDS item is installed, contact with parts, electrical terminals, and circuitry shall be minimized.
- d. Failed ESDS items shall be placed in protective packaging after removal from the equipment.
- e. Probing ESDS items with test leads shall be conducted only within a certified ESD protected area

### **8.5 Equipment Level Installation**

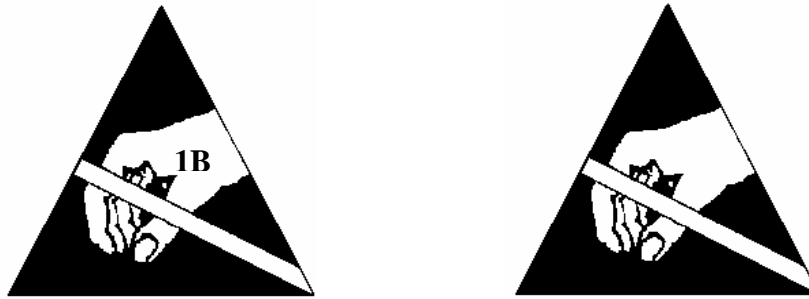
**8.5.1** ESD-protective covering or protective caps on external terminals, interconnecting cables, and connector assemblies shall not be removed until necessary to permit the installation.

**8.5.2** The cable connector pins and cable shield (connector outer shell) shall be grounded prior to engaging a de-energized connector and cable with a mating receptacle connected to an ESDS item. Soft grounding shall be used to avoid rapid discharge.

### **8.6 Identification and Marking**

**8.6.1** ESDS items, equipment, and assemblies shall be identified so as to warn personnel before any potentially ESD-damaging procedure can be performed. Packing lists, inspection reports, travelers, and other paperwork accompanying the hardware shall contain ESDS labels and cautionary notes.

**8.6.2** Alternative identification shall be used as approved by the GSFC procuring activity when the prescribed marking is not present. Approving procuring officials shall be qualified by training as described in 6.1.1.



**Figure 8-1: Sensitive Electronic Device Caution Symbol (with & without sensitivity class level)**

**Note:** *If the Class sensitivity level is not specified within the symbol, or is other than Classes 0, M1, or C1, it will default to Class 1A. Refer to paragraph 5.3.*

**8.6.3** The ESD Protective Item Symbol should be used to identify items which are specifically designed to provide ESD protection for ESDS assemblies and devices. This symbol is illustrated in Figure 8-2.



**Figure 8-2: ESD Protective Item Symbol**

**8.6.4** The ESD common point ground symbol should be used to indicate the location of an acceptable Common Point Ground.



**Figure 8-3: ESD Common Point Ground Symbol**

## 9 ASSURANCE PROVISIONS

### 9.1 Surveillance

**9.1.1** Project Systems Assurance Managers (SAMs) have the responsibility to ensure that processes used for their project are properly controlled and meet requirements. Therefore, SAMs or their designated representatives shall audit ESD controlled areas prior to beginning work on their flight hardware, and thereafter as necessary to ensure compliance to these requirements.

**9.1.2** Code 300 or the area's ESD program monitor shall periodically verify ESD protected areas.

**9.1.3** Code 300 may perform random audits.

### 9.2 ESD Protected Area "PASS" Requirements.

**9.2.1** If the ESD protected area meets the requirements of this manual, it shall be certified as approved for use. The certifier shall initial, date, and enter "Approved" on the ESD Protected Area Test Log (see Appendix A).

**9.2.2** The certifier shall also affix a Certification Sticker (Appendix C) to the work area in a conspicuous location, but not in an area where ESDS items will be processed (e.g., workbench riser, front edge of work surface, etc.). For ESD workbenches inside clean rooms or other restricted areas, the sticker shall be attached to the ESD Protected Area Test Log and filed with the other records for that area.

**9.2.3** The ESD protected area shall remain certified for use unless a discrepancy is noted during use (e.g., broken ground wire, expired calibration date on the continuous wrist strap monitor, etc.) or the verification schedule has not been maintained for more than a year.

**9.2.4** During inspections the Trend column shall be check (✓) indicating that the data is not drifting toward an out-of-tolerance condition.

### 9.3 ESD Protected Area "FAIL" Requirements.

**9.3.1** If an ESD protected area fails to meet the requirements of this manual, it shall have a "**Failed ESD Protected Area**" sign placed in an obvious location indicating the station is out of service for handling ESDS items (See appendix C). The verifier shall initial, date, and enter "Not Approved for Use" and provide a brief description of the problem in the comments box on the ESD Protected Area Test Log. The Area will remain out of service until the discrepant item(s) have been corrected and the ESD Protected Area Test Log has been updated to show the Area acceptable for use. When ESDS hardware has been handled in the area since the last passing verification; that hardware shall be handled as non conforming material and processed according to GPR5340.2.

**9.3.2** The verifying organization and the department responsible for the area shall address discrepancies in a team environment in order to restore the area for use in as little time as practical. Disposition of ESDS items affected by the discrepancy is the responsibility of the organization that owns the items and the organization responsible for the area.

## 10 FORMS

The following forms are a required part of the GSFC ESD Program. Standard versions of items a-d below are available through Code 300. However, organizations are encouraged to modify these forms to be area-specific.

- a. ESD Protected Area Test Log (See Appendix B)
- b. Certification Sticker (See Appendix C)
- c. Failed ESD Protected Area Sign (See Appendix C)
- d. Wrist Straps/Footwear/Hand Tools Logs (See Appendix D)
- e. Other area-specific logs as required by each particular ESD protected area (e.g., humidity log).
- f. If electronic data logging is used, a soft copy of the data shall be available at the ESD protected area for the verifier to review.

## **Appendix A ESD Protected Area Verification Test Procedure**

### **A1. Purpose**

This appendix defines procedures for performing ESD protected area tests.

### **A2. Scope**

This document applies to personnel performing ESD protected area tests or other ESD-related support for GSFC organizations who request such support.

### **A3. Requirements**

#### **A3.1 Personnel Requirements**

The Supplier shall ensure that:

- a. Their ESD program monitor has the appropriate resources and knowledge to implement this procedure (e.g., approved personnel training, current Certificate of Completion of Training, equipment procurement/calibration, etc.).
- b. Personnel providing ESD support have the appropriate knowledge and Certificate of Completion of Training to perform the assigned task and that the verifications they perform are within specified time frames, records are current, and reports are issued as specified herein.
- c. Personnel assigned to this task verify calibration status of test and measuring equipment, make all necessary measurements and observations, and complete all appropriate forms and records as identified in this procedure (e.g., ESD Protected Area Test Log sheets, internal records, etc.).

#### **A3.2 Equipment Calibration**

All test and measuring equipment used to perform the ESD Protected Area Verification Test shall be in a current state of calibration.

### **A4. Equipment list.**

The following equipment (or equivalent) shall be used:

- a. 3M Model 701 Test Kit for Static Control Surfaces
- b. 3M Model 709 Static Sensor
- c. Monroe Electronics Model 287 Ionizer Performance Analyzer

## **A5. Procedure**

### **A5.1 Verifications and Results**

**A5.1.1** The applicable elements of ESD protected areas shall be verified by personnel currently certified in accordance with paragraph A3.1 of this appendix. See Section 9.1 of this manual for personnel responsibilities. The frequency of verifications, conditions of tests, and limits shall be in accordance with Table 7-1 of this manual.

**A5.1.2** Area certifications shall be documented on the ESD Protected Area Test Log (see Appendix B). The ESD Protected Area Test Log (ATL) shall be used for data entry.

**A5.1.3** Measurements shall be compared to previous data for the relevant area in order to identify trends toward a noncompliant condition. If a trend is noted, the organization responsible for the ESD protected area shall be notified so correction can be implemented before failure occurs. Test Methods

### **A5.2 Test Procedures**

#### **A5.2.1 Test 1: Work Surface Resistance**

This test shall be performed by measuring the resistance between two 5 pound, 2.5 inches diameter electrodes. The electrodes shall be positioned 10 inches (25 cm) apart and at least 2 inches (5 cm) from the edge of the work surface. Set megohmmeter voltage to 100 V, measure the resistance after 15 seconds, and record value in the ATL. The area shall be clean and dry prior to performing this test. For older surfaces, the measurement shall be made on the most worn-out area.

#### **A5.2.2 Test 2: Work Surface Grounding**

- a. Measure the resistance between equipment ground (the nearest permanent electrical outlet ground) and the center of the work surface. Use a 5 pound, 2.5 inches diameter electrode at the work surface. Set megohmmeter voltage to 100 V, measure the resistance after 15 seconds, and record value in the ATL.
- b. When checking highly conductive surfaces, a GFCI outlet shall protect personnel. Check the GFCI using the self-test feature in the outlet. Plug a lamp in the receptacle and press the TEST button in the GFCI. The light must go out. Unplug the lamp, press RESET, and record in ATL.

#### **A5.2.3 Test 3: Floor Resistance**

Measure the resistance between two points on the “High Transit” area of the floor at least 12 inches apart. Use a 5 pound, 2.5 inches diameter electrode at the work surface. Set megohmmeter voltage to 100 V, measure the resistance after 15 seconds, and record value in the ATL. This is a minimum test for recertification only and can be used for either floor mats or conductive floors. For initial certification of a newly installed conductive floor follow the test procedure in ESD STM7.1-2001.



**A5.2.4 Test 4: Floor Grounding**

Measure the resistance between the facility ground (the outlet ground) and a point on the floor at least 12 inches away from the floor-to-ground connection. Use a 5 pound, 2.5 inches diameter electrode at the work surface. Set megohmmeter voltage to 100 V; measure the resistance after 15 seconds, and record the value in ATL. This is a minimum test for verification only and can be used for either floor mats or ESD protective floors. For initial certification of a newly installed ESD protective floor follow the test procedure in ESD STM7.1-2001).

**A5.2.5 Test 6: Wrist Strap Grounding**

Resistance shall be measured using an ohmmeter. The measurement shall be made from the wrist strap Groundable Point (Gp) to facility ground in the nearest permanent electrical outlet. Record resistance value in ATL.

**A5.2.6 Test 8: Continuous Monitoring Systems**

Check for alarm to activate when the ground is removed by using a "Cheater Plug," and again by physically removing the cord from the wrist strap while wearing it. This test shall be performed when the CMS is being calibrated or when there is doubt about the reliability of the CMS. For a complete calibration of the CMS, use the manufacturer's recommended fixture and test procedure.

**A5.2.7 Test 9: Stool & Chair Grounding**

The qualification tests for any seating used in an ESD protected area shall be in accordance with ESD SMT12.1-1997. For verification tests, position a 5 pound, 2.5 inch diameter electrode at the center of the seating surface and measure the resistance to the chair's groundable point (a caster or grounding chain shall rest on a conductive surface; use of a metal plate may be necessary on non-conductive floors). The test shall be repeated for the back and arms of the chair, if present. Set megohmmeter voltage to 100 V, measure after 15 seconds, and record the largest resistance measured.

**A5.2.8 Test 11: Humidity**

Relative Humidity shall be constantly monitored using a calibrated hygrometer. The hygrometer shall be in the same room as the work area. Continuously recording chart recorders or automatic logging are recommended. For places where there is no continuous record, a log shall be maintained by the organization responsible for the ESD protected area. The log shall document that the humidity levels are within the acceptable limits. Daily entries shall be made each time the ESD protected area is in use. The verifier shall record the current Relative Humidity in the ATL and review the humidity charts/log for large variations in RH, which indicate that more frequent checks may be necessary.

#### **A5.2.9 Test 12: Ionizers**

For most applications, ionizer performance is considered acceptable as long as the ionizer is in a current status of calibration. Ionizer average decay rate and ion balance shall be measured in accordance with ESD Association Standard Practice ESD SP3.3-2000, and the limits for decay and balance measurements are determined by the ESD classification of the ESD protected area being verified. Since some ionizers tend to collect dust and loose their effectiveness, periodic cleaning and verification of all air ionizers is recommended. The verification tests can be done using a Monroe Electronics Ionizer Performance Analyzer Model 287 or equivalent instrument(s) capable of making the measurements contained in ESD SP3.3-2000. Record decay time and balance on the ATL.

#### **A5.2.10 Test 13: Soldering Iron Tip to Ground**

Soldering iron tips may be checked using a Digital Multimeter and a FR-4 copper-clad PC Board measuring at 2 x 0.5 inches.

- a. Attach one lead of the DMM to the AC outlet and the other lead to the PC Board.
- b. After the iron is at operating temperature, touch the tip of the iron to the far end of the PC Board and measure the AC voltage. It should measure < 2.0 mV AC.
- c. Unplug the soldering iron from the wall while still hot, and check the resistance from the tip of the iron to the ground U-prong in the soldering iron plug. The resistance should be < 20 ohms.

***Caution: Use the PC board to connect the tip of the hot iron to the ohmmeter to avoid burns or damage to test leads.***

- d. For GFCI-equipped soldering irons, use the manufacturer's recommended procedures to check proper circuit operation.

#### **A5.2.11 Equipment & Facility Grounding**

Measure the resistance between the Main Service Box neutral bond and the ESD protected area CPG. This test may require the assistance of the Maintenance Department to access the neutral bond at the Main Service Box. A quick check can be done using a commercial socket tester.

*Note: This test is only required during initial certification of an ESD protected area or if the electrical system in the area has been serviced or modified.*

### **A5.3 Reporting.**

The verification activity will provide a summary report to the ESD program monitor responsible for the area. It shall be retained as described in paragraph 4.3.

### **A5.4 Out of Calibration Test Equipment.**

Only test and measuring equipment in a current state of calibration shall be used.

If a piece of test or measuring equipment is returned from the calibration contractor indicating it was received in an "out of tolerance" condition, records shall be reviewed to determine which ESD protected areas were verified using that piece of equipment since its last known "good" status. A

Nonconformance Report shall be prepared (see GPR 8730.1) documenting the impact of the out-of-tolerance condition on all products or services processed in the areas in question since the last acceptable assessment of calibration. The ESD program monitor shall notify all affected organization(s) and supply them with as much information as possible for them to use in their impact analysis (i.e., dates of prior verifications, how far out of tolerance the equipment was found to be, etc.).

## ESD Protected Area Test Log

Building #		Room #		Work Stn ID #		HBM Class__		ESD Mon.		Lab Mgr			
Test Item		Date:			Trend	Date:			Trend	Date:			Trend
		Pass	Fail	Data		Pass	Fail	Data		Pass	Fail	Data	
Test #													
1. Work Surface Resistance													
2. Work Surface Grounding													
3. Floor (or mat) Resistance **													
4. Floor (or mat) Grounding **													
6. Wrist Strap Receptacle To Ground*													
8. ESD Continuous Monitoring System Alarm resistance threshold level. **													
9. Stool & Chair Grounding **													
10. Mobile equipment resistance to groundable point. **													
11. Work Area Relative Humidity (%RH)													
11. Hygrometer Log Status**													
12. Ionizer Average Decay Rate +1050V to +100V/-1050V to -100V													
12. Ionizer Balance ± 50 Volts													
13 Soldering Iron Tip to Ground													
Test/Measuring Equipment ID and Cal. Due Date	Area Hygrometer	ID		Cal Due		ID		Cal Due		ID		Cal Due	
	Megohmmeter	ID		Cal Due		ID		Cal Due		ID		Cal Due	
	CMS Checker	ID		Cal Due		ID		Cal Due		ID		Cal Due	
	Ionizer P.A.	ID		Cal Due		ID		Cal Due		ID		Cal Due	
	Multimeter	ID		Cal Due		ID		Cal Due		ID		Cal Due	
Comments: Enter "Approved" if tests PASS Otherwise; describe problem and any relevant remarks pertinent to the verification. (Use back of sheet if needed).													
		Verifier's Signature				Verifier's Signature				Verifier's Signature			

\*Measurement not required if a continuous wrist strap monitoring system is used.

\*\*If Applicable

## Appendix C Examples

### Example of Certification/Verification Stickers

This ESD protective workstation is certified compliant to GSFC-WM-001 HBM Class _____ Workbench ID: _____ Certified by: _____ Certification date: _____
---

This ESD protective workstation is verified compliant to GSFC-WM-001 HBM Class _____ Workbench ID: _____ Verified by: _____ Verification date: _____ Due _____
--

### Example of Failed ESD Protected Area Sign

<p>This ESD Protected Area has</p> <p style="text-align: center;"><b><u>FAILED</u></b></p> <p>The requirements of GSFC-WM-001A. It is</p> <p style="text-align: center;"><b>NOT APPROVED FOR ESD WORK</b></p> <p>Failed by: _____</p> <p>On (date): _____</p> <p>For more information contact the area ESD Monitor</p> <p>This notice shall not be removed until the Area is re-inspected</p>
---

### Example of Completion of Training Certificate

<b><i>Completion of Training</i></b>		
TO		
<b><i>GSFC WM-001 in accordance with</i></b>		
<b><i>ESD S20.20-1999</i></b>		
is hereby granted to:		
<u>[name here]</u>		
From: [company name]		
to certify that they have completed to satisfaction		
<b><i>Electrostatic Discharge</i></b>		
as		
<b><i>ESD Program Monitor</i></b>		
Given by [name of organization providing the training]		
_____ [Instructor's name, title]	_____ [Date]	_____ [Track #]

## Appendix D Check Log (example)

[illegible]